Cuoricino and CUORE Double Beta Decay Experiments*

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CUORE and CUORICINO are based on the technique of cryogenic detectors. When operated at low temperature, the absorbers of these detectors have a heat capacity so low that even the small energy released by a single radioactive decay event can be observed and measured by means of a suitable thermal sensor. With crystals of mass near to a kilogram, with NTD Ge (Neutron Transmutation Doped germanium) thermistors, we have reached an energy resolution similar to that of germanium diodes. In addition, thermal detectors allow a wide choice of nuclei to be used for double beta decay searches. We are presently engaged in the experiment CUORICINO in the Gran Sasso underground laboratory and in the R&D for a much-enlarged version of it, CUORE (Cryogenic Underground Observatory for Rare Events). CUORICINO is an array of 44 crystals of TeO_2 each 5x5x5 cm and 18 crystals each 3x3x6 cm. With its mass of approximately 40 kg, CUORICINO is by far the most massive cryogenic set-up in operation. Due the large isotopic abundance (34%) of the double beta decay candidate ^{130}Te, no isotopic enrichment is required, but two of the 3x3x6 cm crystals are enriched in ^{130}Te and two other in ^{128}Te to investigate two-neutrino double beta decay. In only three months of operation, CUORICINO has obtained a 90% c.l. limit on the lifetime against neutrinoless double beta decay of 5.5 x 10^{23} yr, corresponding to an upper limit on the average neutrino mass ranging from 0.3 to 1.7 eV depending on the value of the nuclear matrix element that is used. This result is at the level of the best limit obtained from many years of searches for the double beta decay of ^{76}Ge.

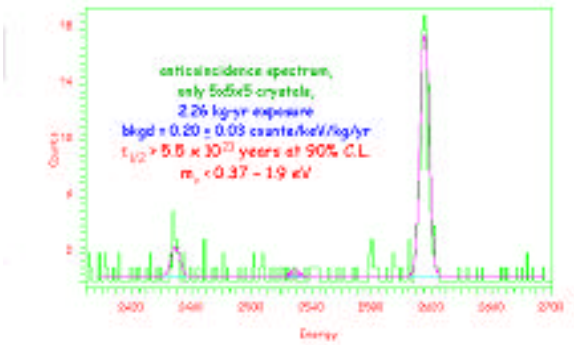

Figure 1. Sum of the spectra from the 5x5x5 cm crystals observed in Cuoricino in the region of the neutrinoless double beta decay energy (2529 keV).

CUORE will consist of an array consisting of 25 columns of 10 planes of 4 TeO_2 crystals each 5x5x5 cm of for a total of 1000 crystals with a mass around 760 kg. Each tower will therefore be similar to the single tower of CUORICINO, which consists of 13 planes. As far as time is concerned, CUORICINO is now running and its larger brother CUORE will be available in four years from the start of construction (likely summer of 2004). We would like to add that the flexibility of CUORE would allow searches on other interesting double beta decay candidates.

The evaluation of the expected sensitivity of CUORE is obviously subject to assumptions on which a Monte Carlo calculation is based. In our case we prefer to base our prediction on the Monte Carlo simulation adapted to our present results of CUORICINO. We would like to note that the present background of CUORICINO in the region of neutrinoless double beta decay (0.20±0.02 counts/keV/kg/year) is in excellent agreement with our previously predicted value (0.22 counts/keV/kg/year). In our present measurement we find that this background is mainly due to the surface contamination of copper and crystals and we have recently found a way to reduce it by an order of magnitude by surface treatment. Taking into account that the structure of CUORE allows a large suppression of background by applying the anticoincidence method we can guarantee a conservative value of background of 0.01 counts/keV/kg/year. We believe that in the next four years we can achieve a further improvement in the energy resolution, in the radioactive contamination, and in the neutron and cosmic ray background. Thus, it is reasonable to predict a background of 0.001 counts/keV/kg/year for CUORE. As a consequence we believe that the CUORE sensitivity can be in the few tens of millielectronvolts for the average neutrino mass.

References

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